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## Increasing Pulmonary Artery Catheter Education Among CCU Nurses: A Quality Improvement Project

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**Increasing Pulmonary Artery Catheter Education Among CCU Nurses: A Quality  
Improvement Project**

Kayla Fisher

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## Executive Summary

**Title:** Increasing Pulmonary Artery Catheter Education Among CCU Nurses: A Quality Improvement Project

**Background and Significance:** Among the patient population in the Cardiac Care Unit (CCU) at a large academic medical center in Seattle, pulmonary artery (PA) catheters are commonplace. PA catheters are invasive central venous access devices with the ability to measure hemodynamic parameters that reveal information about the functionality and cardiac output of the heart. Should values obtained from PA catheters be incorrectly measured, serious complications could arise. Appropriate management of this device requires specialized expertise which is usually limited to cardiac critical care and surgical settings.

**Problem and Purpose Statement:** Multiple studies report mismanagement of PA catheters and incorrect measurement of the values derived from them in the absence of a specialized education program. Sufficient evidence supports the effectiveness of content-specific training for improvement of PA catheter knowledge. The CCU at this healthcare facility does not have a routine ongoing education program specifically dedicated to PA catheter management after the initial onboarding educational process for nurses. The primary aim of this program is to determine whether knowledge increases among CCU nurses who participate in a PA catheter training program. A secondary aim of the project is to evaluate the effectiveness of the developed PA catheter training program itself.

**Methods:** A PA catheter educational training program and an identical pretest and posttest were developed from published or validated resources and test questions. Concepts covered in the module includes expected standards of care, a brief overview of the basics of PA catheter management, the process of measuring hemodynamic values, and the mechanics of measuring

end-expiration and its significance. Test questions for the pre- and posttest that demonstrated knowledge of the aforementioned topics were chosen. Ten CCU charge nurses participated in the pretest, intervention, and posttest. Tests were scored and compared to assess change in knowledge. Descriptive statistics of the paired data were calculated and analyzed quantitatively for change.

**Results/Outcomes:** Significant improvement was recognized after participants engaged in the educational program. The mean test score increased, answer variability decreased, and a p-value of 0.01 resulted demonstrating statistical significance. This effectively demonstrates that CCU nurse knowledge of PA catheters and their management improved. Inaccurate measurement of hemodynamic values obtained from a PA catheter is associated with increased mortality in critically ill patients (Claire-Del Granado & Mehta, 2016).

**Sustainability:** Promoting sustainability, this program will be used to educate nurse 'super-users'. Since the implementation of the project, interdisciplinary interest has been expressed. Further aims are to educate a wider array of health professionals including physicians, advanced practice nurses, and physician assistants. In addition to the efficacy of the intervention, this educational program is inherently valuable within this healthcare facility due to the lack of published and scholarly resources dedicated to PA catheters.

**Implications:** Increased PA catheter knowledge among project participants indicates not only that the program content itself was efficacious at educating nurses; it also demonstrates that the educational program will likely be successful at educating other interdisciplinary staff in the CCU as well. The results also imply patients will receive safer and more effective care, thus improving patient care outcomes.

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## **Increasing Pulmonary Artery Catheter Education Among CCU Nurses**

A pulmonary artery (PA) catheter is a specialized piece of equipment that requires an advanced skill set to manage appropriately (Von Rueden, 2020). Without a specific PA catheter education program, studies show that users demonstrate both a lack of confidence and knowledge in their abilities to properly manage the device. In the Cardiac Care Unit (CCU) at a large academic medical center in Seattle, though there is ample critical care education given routinely, there is no specific training pertaining specifically to PA catheters after the initial onboarding phase. Incorrect management of PA catheters causes misinterpretation of critical information about the heart based on inaccurate data, leading to mismanagement of patients (Oldenburg et al., 2019). The clinical status of patients in the CCU is fragile and tenuous, as changes in the heart's function and rhythm can occur rapidly. This can cause devastating consequences for critically ill cardiac patients whose clinical status can progress from stable to unstable within minutes to seconds (Von Rueden, 2020). In an effort to improve patient care, a training program dedicated specifically to PA catheters will be piloted to determine if an educational program would prove successful as reported in the literature.

### **Background and Significance**

In the CCU at this prominent teaching facility, PA catheter use in critically ill cardiac patients is very common; nearly half of this population at any given time has a PA catheter in place. This is an invasive central venous access device that is most often placed in the internal jugular vein for a period of hours to weeks (Oldenburg et al., 2019). It measures parameters such as central venous pressure (CVP) and pulmonary artery pressure (PAP), both critical values monitored in patients with heart failure and undergoing heart surgery (Sjodin et al., 2019; Von Rueden, 2020).

The management of a patient's fluid status can have serious implications if not managed properly (Sjodin et al., 2019; Von Rueden, 2020). Should the CVP, a measure of the circulating blood volume at any given time, be measured incorrectly patients may receive an excess or deficit of fluids (Claire-Del Granado & Mehta, 2016). For instance, if the CVP is estimated falsely low, this could result in the patient having excess fluid circulating throughout their bloodstream necessitating extracorporeal support to remove it (Claire-Del Granado & Mehta, 2016). Should the CVP be estimated falsely high, this could result in the patient having a deficit of fluid circulating throughout their bloodstream (Claire-Del Granado & Mehta, 2016). This could result in the patient going into hypovolemic shock, a state in which an inadequate supply of blood reaches the body's organs (Claire-Del Granado & Mehta, 2016). Both of these conditions illustrate the manner in which the mismanagement of a PA catheter can lead to a patient's death.

As explained, CVP must be measured carefully and accurately when obtaining data from a PA catheter. Sjodin et al. (2019) found that the majority of nurses in the sixty-one subject cohort incorrectly identified the correct placement of a transducer, a vital part of accurate PA catheter monitoring. Should this step be performed incorrectly, it results in inaccurate data measurements (Sjodin et al., 2019). During CCU orientation, there is a cardiac hemodynamic overview class encompassing PA knowledge and skills. Material pertaining to PA catheters is included in the didactic test at the end of the orientation period. CCU nurses are expected to measure these objective patient data values, yet after the initial onboarding phase, there is no ongoing curriculum specific to PA catheters.

Unsurprisingly, evidence shows that there is benefit in retraining nurses after their initial training of a skill (Lee et al., 2021). In one study, attitude, self-evaluation, and confidence of

sixty-one nurses were evaluated after retraining eighteen core nursing skills (Lee et al., 2021). Lee et al. (2021) found that scores in all categories improved, showing that an increase in education has the potential to improve the ability of nurses to use PA catheters.

### **Problem Statement**

There is no routine ongoing training or education program dedicated specifically to PA catheter management after the initial onboarding phase in the CCU at this hospital. Sufficient evidence as supported above demonstrates the effectiveness of content-specific training programs for improving knowledge of PA catheters, central lines, and hemodynamics. The intent of this project was to determine whether a program focused on appropriate PA catheter use, management, and troubleshooting techniques would help improve nursing knowledge regarding PA catheter management.

### **Clinical Question**

Among CCU nurses at a large academic medical center in Seattle, will a follow-up PA catheter education program improve PA catheter knowledge?

### **Review of Literature**

#### **Search Strategy**

Inclusion criteria started with a date range limited to articles published between 2016 and 2021. For a search conducted in June 2021, Medline and CINAHL were used to research relevant articles. The search specific phrase “PA catheter education program” was initially used as a keyword. This produced minimal results and suggested a knowledge deficit. The phrases “ICU education program”, “nurse education”, and “swan-ganz catheter training” were then subsequently searched. The inclusion criterion was expanded to include alternative phrases that did not encompass the project entirely, but possessed similar aspects, which proved useful in

finding articles with relevance. Literature with different types of educational training was also searched, including in-person and online offerings. Articles that met the above requirements and had applicability to PA catheters or education training programs were included.

Experimental studies, specifically randomized control trials (RCTs) and quasi-experimental studies, were searched for. No applicable RCTs regarding PA catheters or other similar education programs were found. Four quasi-experimental studies were found. Non-experimental studies were also searched for, and one relevant cohort study was identified. Qualitative studies were excluded since the focus of this scholarly project is on quantitative evidence. In addition, for supporting evidence in this paper, three additional articles using the same criteria were used. Three other online informational resources were included pertaining to theoretical framework, the organization, and supporting information. Thus, a total of eight studies and three additional resources are included in this review of literature. Themes encompassing the evidence found in these searches are discussed further.

### **Lack of Confidence in Abilities Related to PA and Central Venous Catheters**

The literature review revealed a common theme in most articles; in the absence of a specific education program study participants self-report a lack of confidence in their abilities to properly utilize and manage a PA catheter. In a population of ICU nurses that had limited education and exposure to PA catheters, Oldenburg et al. (2019) found that they generally identified themselves as unconfident in their abilities to utilize one appropriately. Davidson et al. (2020) uncovered a similar finding while surveying cardiology fellows who reported a lack of certainty in inserting and managing PA catheters.

Akin to the low confidence levels discovered regarding PA catheters among many study participants, one study found this to be true about central venous catheters (CVCs) as well

(Sharour et al., 2018). CVCs are centrally placed intravenous catheters that terminate in or just distal to the heart, similar to PA catheters, but with less expertise required to manage (Sharour et al., 2018; Sjodin et al., 2019). Sharour et al. (2018) asserted that in their sample of one hundred oncology nurses, the majority self-reported a lack of confidence in CVC knowledge, having not taken a specific training program. Though these studies examined different populations, they each reached the same conclusion.

### **Insufficient PA Catheter Knowledge**

Sharour et al. (2018) discovered that many of their study participants also lacked CVC knowledge. Similarly, Davidson et al. (2020) found that cardiology fellows in this study not only showed low confidence levels in their ability to use PA catheters, but they performed poorly in terms of knowledge regarding insertion and management as well. This measurement was taken both prior to and after any education intervention and compared (Davidson et al., 2020). Though these two articles studied different invasive monitoring devices, they both reached the same conclusion that knowledge of the respective devices increased after implementation of their chosen intervention.

Sjodin et al. (2019) found that among a cohort of sixty-one critical care nurses who routinely utilized CVCs, there was great variation in the technique used to obtain CVP values, resulting in widely varied results between participants. Wise et al. (2016) reported low levels of knowledge about PA catheters among their cohort as well. These participants had not received PA catheter-specific education nor had they been exposed to PA catheters regularly (Wise et al., 2016). A lack of PA catheter education is compounded by the absence of a setting that routinely utilizes PA catheters and exacerbates this knowledge deficit (Von Rueden, 2020). As the only non-experimental study included in the literature review, this study focused on medical students'

self-reported understanding of PA catheters (Wise et al., 2016). Most medical students in this population had never encountered a PA catheter (Wise et al., 2016). Prior to any intervention, students reported low levels of understanding about PA catheters (Wise et al., 2016). A PA catheter knowledge deficit is evident through the results of these studies.

### **Education Programs as an Intervention**

The literature review revealed that a commonly used tactic for improving consistency among PA catheter users included utilizing an education program or module. Some of the training was conducted in-person, while some was conducted online. Gilfoyle et al. (2017) found that after a one-day in-person training course, their sample of staff including ICU nurse practitioners, residents, registered nurses, and respiratory therapists improved in terms of clinical performance. Sharour et al. (2018) also used in-person training to teach specifically about PA catheter utilization. Instead of a one-day course, such as the one used by Gilfoyle et al. (2017), Sharour et al. (2018) used an in-person twenty-five-hour training course. The interventions differed in content, as one study focused on PA catheters while one focused on PALS, a different but applicable critical care topic. However, both studies showed relevance to my project as evidenced by established improvements in study participants' levels of confidence and knowledge after in-person training.

Oldenburg et al. (2019) studied a population of ICU nurses that had very limited experience with PA catheters. Because learning opportunities using a PA catheter itself were limited, these ICU nurses were educated using an online module (Oldenburg et al., 2019). The study conducted by Wise et al. (2016) also utilized an online module training program to teach a group of medical students, a population with virtually no PA catheter experience. In both studies, similar to the in-person training programs, online training produced improvements in terms of

both level of confidence and knowledge.

It is difficult to decide which method proved more effective. However, one particular study compared the two modes. Davidson et al. (2020) compared cardiology fellows traditionally trained in-person to those trained via online simulation. Both groups performed similarly in categories of PA catheter utilization confidence and knowledge (Davidson et al., 2020). Thus, researchers did not reach a resolution as to which method is superior and suggested that either method of teaching could be used.

### **Post-Study Surveys as a Data Collection Tool**

Many studies used post-study surveys to gather information. They proved particularly helpful in assessing subjective information, such as reflection upon one's own confidence in utilizing PA catheters properly. Post-study surveys largely revealed increases in participants' levels of confidence after undergoing said intervention as well. The study conducted by Davidson et al. (2020) utilized a post-study survey to evaluate participants' confidence in their abilities post-training. Using this data collection method, increases in level of confidence were established, as discussed previously (Davidson et al., 2020). In a similar fashion, the previously discussed study conducted by Oldenburg et al. (2019) suggested that the intervention utilized was successful. These researchers found that participants' confidence in their own abilities to correctly interpret data after completing an online education course improved with statistical significance of  $p < .001$  (Oldenburg et al., 2019). A post-study survey allowed researchers to reach this conclusion (Oldenburg et al., 2019). In both studies, the participants reported a self-perceived improvement in their confidence in utilizing PA catheters.

The post-study survey method not only proved useful in evaluating levels of confidence, but also with knowledge about PA catheters. Wise et al. (2016) used post-study surveys to assess

whether knowledge of PA catheter management and utilization increased post-intervention. Study participants self-identified that their perceived level of knowledge increased with statistical significance of  $p < .001$  after participating in the education program (Wise et al., 2016). This study differed from the previous two in the sense that it evaluated participants' knowledge instead of confidence, but they are similar in that they evaluated self-perception.

### **Pretests and Posttests as a Data Collection Tool**

In contrast to post-study surveys that require subjects to self-reflect, pretests and posttests objectively evaluate improvements through scoring. To measure whether the education-based interventions were successful in increasing knowledge about PA catheters, these tests were conducted before and after each study's intervention. Davidson et al. (2020) not only measured increases in participants' levels of confidence through post-study surveys, but this study also used a pretest-posttest experimental design to test cardiology fellow PA catheter knowledge. Specifically, the researchers of this study evaluated understanding of PA catheter insertion and associated hemodynamic interpretation (Davidson et al., 2020). Researchers measured this using a checklist for proper PA catheter insertion and a hemodynamic interpretation quiz (Davidson et al., 2020).

Sharour et al. (2018) originally revealed poor pretest scores regarding knowledge about CVC use among ICU oncology nurses. After implementation of the training module, posttest scores improved with a p-value of 0.001 (Sharour et al., 2018). Though Gilfoyle et al. (2017) used a training course focusing on PALS expertise, this study also used a pretest and posttest format to measure associated clinical performance. Improvements in clinical performance occurred after completion of the training intervention with a statistically significant p-value of  $< .0001$  (Gilfoyle et al., 2017). In each of these studies, posttest scores were compared to pretest

scores to measure improvements in the variables being evaluated.

### **Review of Literature Conclusion**

This thorough literature review supports the need for and divulges effective ways of creating and implementing PA catheter education. This review revealed that in the absence of relevant PA catheter education, health professionals report or demonstrate both a lack of knowledge and confidence in their ability to manage them. The literature supports educational programs as effective interventions to combat this problem, with evidence to support the success of both in-person and online training. It also suggested effective ways to measure whether improvements occurred using both post-study surveys as well as pretests and posttests.

### **Organization Assessment**

Continued education is of utmost importance to the large academic medical center in which this project takes place in. The hospital's mission is "to improve the health of the public" (University of Washington Medical Center [UWMC], 2021). The institution's vision focuses on helping patients and families reach their individual goals for wellness and disease management, an educational environment for health professionals, and a research enterprise for scientists to advance their knowledge and grow clinical innovations (UWMC, 2021). Creating and implementing a PA catheter education program fulfills their vision of providing an environment that emphasizes education for health professionals.

A Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis was conducted to understand the specific needs of the CCU in this facility. Strengths included a work environment conducive to learning as well as the existing positive relations among providers and nurses. Weaknesses largely included stressed and over-worked staff due to the difficulties of working during the COVID-19 pandemic. Opportunities included having a group of APNs (advanced

practice nurses) passionate about implementing a PA catheter education program, providing much support for the success of this project. Threats included CCU management not prioritizing this project amid a hectic pandemic.

### **Purpose Statement**

The purpose of this DNP project was to create a training program to increase the level of knowledge in PA catheter management in the CCU. A secondary aim of this project was to determine whether the educational intervention itself is efficacious, leading to increased understanding, knowledge, and management of PA catheters. This project involved the development and implementation of PA catheter management nursing education. The effectiveness of this project was measured via statistical analysis of participant results of pretest and posttest data.

### **Theoretical/ Conceptual Framework**

To guide the implementation of this project, the Iowa model was used. The first step of this model asks whether the topic is of priority to the organization (G. Ma & N. Solvang, personal communication, July 5, 2021). As mentioned, multiple APNs at this teaching facility were involved in developing the PA catheter education project. It is supported by administration, management, and providers alike. This created an easy transition to the next step, forming a team. This team consisted of a nurse, a nurse educator, a clinical nurse specialist, and a nurse practitioner. Not only was it beneficial to hear the opinions of a wide variety of members, but this was also helpful for maintaining organization support and for implementation and sustainability of the project.

The IOWA model's success depends upon the presence and synthesis of current research (G. Ma & N. Solvang, personal communication, July 5, 2021). Regarding the importance of

accurate PA catheter measurements, reasons for the lack of these, the presence of an education program as an intervention, and the success of pretests and posttests as measurement tools, there is a sufficient research base. The model next poses the question of whether the change is appropriate and realistic for adoption into practice (G. Ma & N. Solvang, personal communication, July 5, 2021). Since a knowledge deficit related to PA catheters was established with a thorough review of the literature, the project need was clearly identified as were its supporters. As a result, this project was both appropriate and realistic.

A strength of the IOWA model is that it focuses on bedside, frontline practice measures (G. Ma & N. Solvang, personal communication, July 5, 2021). Obtaining hemodynamic values from a PA catheter requires intensive frontline bedside care (G. Ma & N. Solvang, personal communication, July 5, 2021). It also supports the use of ‘change champions’, who are individuals who become experts in the subject and who can then provide help to others (G. Ma & N. Solvang, personal communication, July 5, 2021). If successful, this education will be used to educate CCU nurses to become PA catheter ‘super-users’, who are nurses who may serve as a resource to other nurses who lack experience or have questions about PA catheter management. Thirdly, this model is very successful in large organizations (G. Ma & N. Solvang, personal communication, July 5, 2021). This hospital is a large, 630-bed level-one trauma center teaching facility, with an abundance of resources. Therefore, there was not a facility in Washington better suited for this project to take place in.

Benner’s novice-to-expert nursing theory is used to direct the content of the project. This theory explains that through education and experience, a nurse develops skills that help them progress through various levels of expertise from novice to expert (Petiprin, 2020). In this project, a group of nurses with differing ranges of experience were chosen and given education

on PA catheters to progress from levels ranging from competent and proficient, to expert. This theory emphasizes the movement of nurses from relying on abstract principles and rules to relying on personal experiences and critical thinking skills to guide their actions (Petiprin, 2020).

## **Methodology**

### **Project Design**

The format of this project included the administration of a pretest, an educational module, and a posttest to a group of CCU nurses to evaluate the effectiveness of the educational material. The pretest and posttest consisted of specific questions regarding the accurate utilization and troubleshooting of PA catheters. Both the pretest and posttest consisted of the same ten questions. After participants took the pretest, in an effort to not skew the posttest answers, the results were not revealed. Immediately after participants completed the educational intervention, they took the posttest. The scores were measured quantitatively so that improvements before and after training were easily measurable and recognizable. This project also served as a pilot program for the CCU to implement this training for the education of nurse 'super-users'.

The educational program consisted of components important for utilizing a PA catheter accurately. Specifically, this included expected standards of care, a brief overview of PA catheter management, methods of obtaining hemodynamic values, instructions in which to measure end-expiration and its significance, and troubleshooting tips. Educational curriculum included various published and validated information and instruments, including the American Association of Critical Care Nurses (AACN). The developed training module was a video presentation consisting of a PowerPoint with subsequent audio providing narration and explanation.

This project effectively answered the clinical question, will the creation of a specific follow-up PA catheter education program increase PA catheter knowledge among CCU nurses?

It objectively measured nurse knowledge before and after the educational intervention. The answers to the questions of the pretest were not revealed and the same posttest was administered after the education program. Participants engaged in the pretest, education module, and posttest in immediate succession. Therefore, it was deduced that any score improvement was a result of the training provided. Quantitative increases in test scores indicate that participants were effectively educated about PA catheters.

### **Setting**

This project will take place in the CCU at a hospital with a 20-bed cardiac intensive care unit where many patients have PA catheters. Nurses are accustomed to caring for patients with diagnoses including but not limited to cardiogenic shock, myocardial infarction, and pulmonary hypertension, all of which often elicit the use of a PA catheter. Participants completed the pretest, educational intervention, and posttest independently via the internet. As such, the setting of the testing and intervention was variable.

### **Measurement Tools/ Instruments**

After conducting a thorough literature review and consulting the help of SPU's science librarian, no single instrument or tool exists that specifically measures components. This includes a brief overview of the basics of PA catheter management, the process of measuring hemodynamic values, and the mechanics of measuring end-expiration and its significance. Therefore, a pretest and posttest tool was developed from a compilation of published and validated practice test questions from various credited sources.

### **Participants**

CCU charge nurses representing both day and night shift comprised the cohort of participants. The CCU nurse manager provided a list of charge nurses from which participants

were derived. The forum under which the tests collected data did not ask for any identifying information, therefore results were not traceable to specific individuals. This group constituted a total of ten participants

### **Intervention and Data Collection**

The educational intervention and data collection occurred in May 2022. The principal investigator sent an email invitation to potential participants explaining the intent of the project, instructions, and a timeline of one week for completion. The invitation email also mentioned the manner in which results would be utilized as well as individuals that would have access to the anonymous data. Participants provided their implied consent by clicking a link embedded in the email. This was explicitly explained and redirected them to the project content. From May 2022 through June 2022, data was compiled and evaluated for presentation of the DNP scholarly project at SPU in September 2022.

### **Ethical Considerations and IRB**

This project involved providing training and testing to willing nurse participants in the CCU. Patients were not involved in the project. Participants were compensated for their participation, which may have raised ethical considerations of coercion. However, participants were compensated for only one hour of their regular pay rate which posed a minimal risk. IRB exemption was obtained through SPU. Since this project is not considered research by the academic facility in which it was conducted, IRB approval or exemption did not need to be obtained through this hospital. This was confirmed with the Associate Director for Operations of the Human Subjects Division of research at this institution.

### **Analysis**

After participants completed the PA catheter educational program, results from the posttest were compared to those from the pretest. The mean scores of the pretest and posttest were each calculated based upon the proportion of participants that answered each question correctly. From this information, analysis of variance was performed. A paired t-test was used because the same group of participants was tested twice using the same questions. Specifically, a two-tailed paired t-test was selected to identify whether knowledge increased, decreased, or stayed unchanged, which is expressed as a change occurring in either a positive or negative direction of normally distributed data. This test produced a p-value which revealed information about the statistical significance of the data. The null hypothesis stated that  $H_0 =$  PA catheter knowledge will not improve, whereas the alternative hypothesis stated that  $H_a =$  PA catheter knowledge will improve.

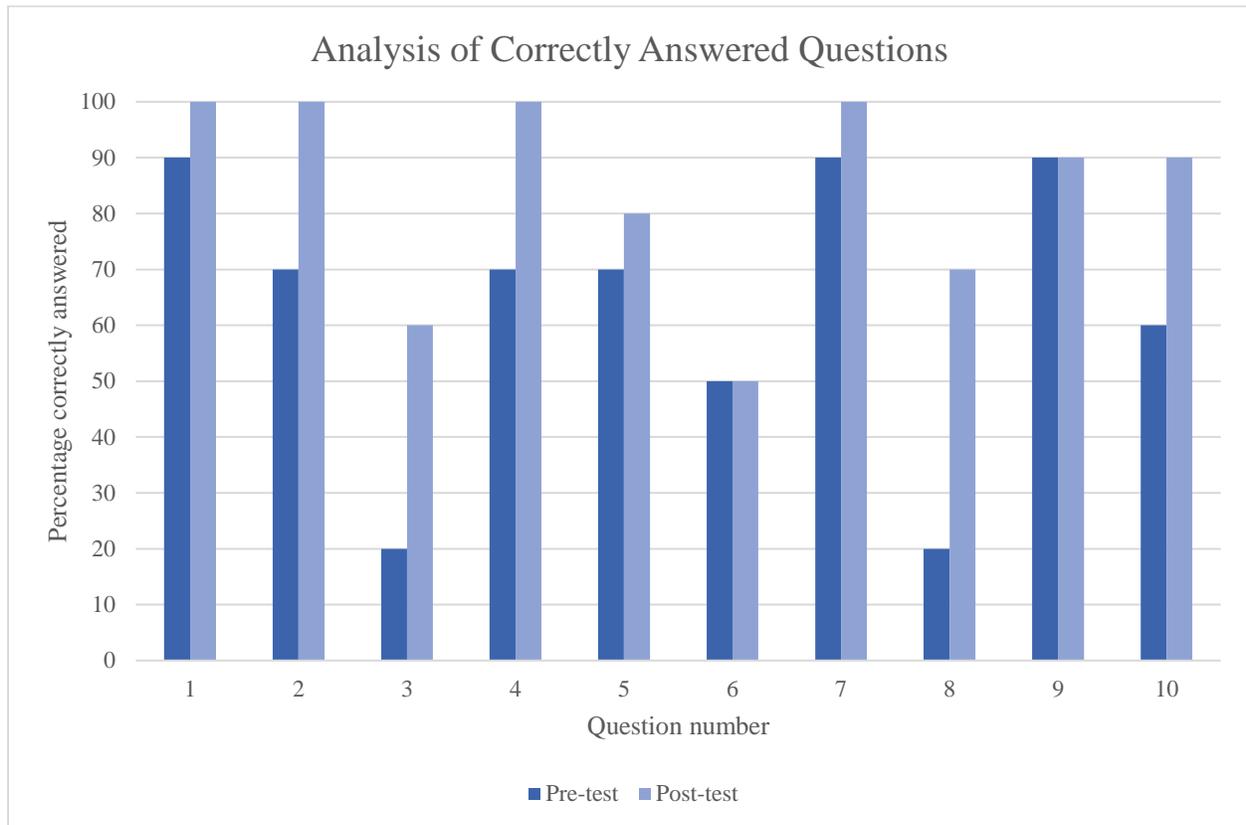
With sample sizes less than 30, the central limit theorem does not apply. Instead, the t-distribution must be used. This distribution is similar to the standard normal distribution used in the central limit theorem, but with a different shape depending on the size of the sample. Additionally, instead of z-values, t-values are used for confidence intervals. These t-values are typically larger because of the smaller sample of participants, and thus produce larger margins of error as well. T-values are listed by degrees of freedom, suggesting that a larger t-score indicates a greater difference among the two test groups. This is a key determinant in assessing the validity of the null hypothesis. As with large samples, the t-distribution assumes that the data are normally distributed.

The score of each individual pretest question was compared to the score of each corresponding question on the posttest. An improvement in score was noted in eight of the ten test questions, albeit to varying degrees. In two of the ten test questions, the same score was

noted in both tests. There were zero questions in which the score decreased from pretest to posttest (Figure 1).

Mean test scores increased from a value of 0.63 on the pretest to a value of 0.84 on the posttest. The 95% confidence interval if this were repeated would be 0.13, which decreased from a pretest value of 0.19. This decrease indicates a lessened degree of variability in responses and thus more reliable data (Figure 2).

Further analyzation using a two-tailed paired t-test revealed statistically significant data with a p-value of 0.01. This falls under the parameter of  $p < 0.05$  that is required to claim statistical significance. Therefore, the null hypothesis is rejected and the alternative hypothesis that PA catheter knowledge will improve is upheld. The two-tailed t-test produced a t-stat value of -3.33, showing marked improvement from pretest to posttest knowledge. This is a high value, which provides ample evidence to reject the null hypothesis.

**Figure 1**

*Note.* This chart demonstrates and compares the proportion of participants that answered each question correctly in both the pre- and posttest.

**Figure 2**



*Note.* This chart demonstrates the mean test scores calculated from the score of each question in both the pre- and posttest. The pretest mean test score was 0.63 and the posttest mean test score was 0.84. The 95% confidence interval of each test is shown by the vertical brackets. The pretest lower and upper confidence interval is wider at 0.44 and 0.82 respectively and the posttest lower and upper confidence interval is narrower at 0.71 and 0.97 respectively.

## Discussion

Results of the pre- and posttests indicate that the education program was successful in improving PA catheter knowledge among CCU nurses. The data is statistically significant, displaying improvements made between pretest and posttest scores and a decrease in variability among responses. Both aspects of the results showcase the reliability of the data. This demonstrates that though participants may have initially felt unsure about some aspects addressed on the test, they gained clarity after partaking in the intervention.

The results produced by the PA catheter education program are consistent with the findings found in the review of literature, where knowledge improved after educational intervention. Davidson et al. (2020) found that participants performed poorly on a hemodynamics quiz in the absence of PA catheter education, but when provided with this performed markedly better and showed statistically significant results with a p-value  $<.001$ . Similarly, Sharour et al. (2018) uncovered poor pretest knowledge about central line use before implementation of a training module but reported afterward that posttest scores improved with a p-value of 0.001. The results of these studies align with those seen in this project, which produced a statistically significant p-value of .01.

In addition to the discovery that PA catheter knowledge improved because of participating in the education program, the results also reveal areas in which the participants need improvement. The findings gleaned from this project are consistent with those from the review of literature. This project, like Sjodin et al. (2019), addressed the technique used to obtain CVP values. Sjodin et al. (2019) discovered a high level of variation in technique used by critical care nurses to measure CVP, resulting in a wide range of values. This was echoed by test question eight of this project which inquired about a critical component involved in CVP

measurement (Figure 1). Twenty percent of participants answered this question correctly on the pretest in comparison to the seventy percent of participants that answered this question correctly on the posttest. Though the proportion of correct answers improved for this question, similar notions were revealed.

Davidson et al. (2020) found that many of their participants lacked knowledge of hemodynamic waveform recognition. This notion is echoed in question three of the pre- and posttest of this project, which involves PA waveform analysis and selection of an appropriate intervention. Twenty percent of participants identified the correct answer on the pretest and sixty percent did so on the posttest (Figure 1). Again, test scores improved but areas for improvement were similar to those of other studies.

Analysis revealed the effectiveness of the developed PA catheter program itself. There were two questions in which participants scores did not improve. Figure 1 demonstrates that for question six, both the pre- and posttest average score was fifty percent, indicating that the question may not have been clear or addressed well in the education material. Upon reflection of this question, it is evident that it required a high-level of critical thinking, but it also was misleading. Figure 1 also demonstrates that for question number nine, both the pre- and posttest average score was ninety percent, indicating that participants may already have sufficient knowledge in this area of PA catheter expertise. In contrast, this question merely required recall and did not require critical thinking. These findings indicate that for use in the future, these questions may need revision or redaction. The unveiling of areas in which nurses show need for improvement should not be misunderstood. It is a valuable asset that contributes to the sustainability and longevity of this program.

### **Limitations**

A small sample size of ten nurses comprised the participant pool for this project. However, there are only a finite number of charge nurses from which the participant cohort was derived. Additionally, only ten participants were approved by CCU nurse management for compensation using project time. The study produced reliable results, but a larger number of participants would have likely increased reliability.

The small selection of research and resources involving PA catheters also imposed a limitation on the review of literature. There is a surprisingly small body of literature specifically dedicated to PA catheters. Thus, research involving similar critical care topics was used as well. Though it would have been ideal to include only PA catheter-specific research for the literature review, the subjects of these resources were closely related. However, the educational resources used to develop the module pertained specifically to PA catheters.

This limited selection of resources also posed a challenge in the creation of the pretest and posttest. To ensure credibility of the project, test questions could be derived from published or validated sources only. In addition to the lack of literature regarding PA catheters, there are even fewer educational resources that include published test questions. They were derived from a journal article and published critical care practice test materials. This restriction may have reduced the efficacy of the project since the applicable test questions found did not encompass every topic discussed in the education module.

### **Sustainability**

The goal of this project has always been to create an education program that is effective in improving nurse knowledge about PA catheters. Moving forward, it is intended to be used to create CCU nurse ‘super-users’. This program serves as a pilot program for this purpose. The lead APN in the CCU has already initiated a plan for creating a ‘super-user’ program, thus

fulfilling the original goal of this program.

Since the implementation of this intervention, great interest has been generated in using the PA catheter education module to teach the entire interdisciplinary team. Attending physicians have requested the module be used to educate fellows and residents in the cardiology and internal medicine programs, and lead APNs have requested to utilize it to improve upon PA catheter knowledge among all APNs and physician assistants. This interest will ensure this program's sustainability, even as it is continuously revised.

Furthermore, there is a surprisingly small body of published curriculum and scholarly resources regarding PA catheters. The material that does exist often does not comprehensively address PA catheter management. This education program created for this project may serve as a valuable resource to a setting that frequently utilizes PA catheters.

### **Implications for Practice**

The goal of this project was to improve PA catheter knowledge among CCU nurses. Since this has proven successful with statistically significant results, the nurses that participated in this project have the skills and expertise to manage patients with PA catheters with greater precision and accuracy. This knowledge will then be extended to other nurses by way of 'super-users' and will be used by physicians and other providers to improve their practice.

The assumption is that patients will receive safer, more informed care and have better outcomes. Though patient outcomes are multifactorial and complicated to measure, it goes without saying that increased knowledge leads to improved care. To illustrate that point, Claude-Del Granado & Mehta (2016) found that incorrect measurement of hemodynamics and mismanagement of a PA catheter or central line is associated with increased mortality in critically ill patients. The implication can be drawn from both this study and the PA catheter

education program that the care and management of critical care patients will be improved with increased expertise.

### **Conclusion**

This project aimed to improve CCU nurse knowledge of PA catheters, as there was no ongoing education dedicated specifically to them. A meticulous, evidence-based education program, pretest, and posttest were created to provide this training and evaluate the efficacy. The results showed statistical significance, demonstrating that the goal was achieved. There is a plan set in place to continue this education program and ensure its sustainability.

The PA catheter is a specialized tool used only in cardiac critical care or surgical settings. Patients who have a PA catheter are nearly always in a fragile state, and the mismanagement of this device can lead to serious complications. Literature and existing training regarding its proper management is scarce, which provides even more reason to educate those taking care of these tenuous patients. The creation of this PA catheter education program provides an opportunity for patient outcomes to improve, which is ultimately the goal of all healthcare measures.

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